II. *An Account of ſome new Experiments in Electricity, with the Deſcription and Uſe of two new Electrical Inſtruments. By Mr.* Tiberius Cavallo, *F. R. S. communicated by the Preſident.*

Read Nov. 25, 1779.

PROFESSOR LICHTENBERG, of Gottingen, ſome time ago made an experiment upon the electrophorus, an account of which was firſt received in London towards the latter end of the year 1777. The phenomena attending the experiment are very entertaining and various, but I do not know that any perſon ever offered a ſatisfactory explanation of them. The author himſelf, in his paper entitled "*De nova methodo* "*naturam ac motum Fluidi Electrici inveſtigandi Com*"*mentatio prior*," wherein he gives an account of the experiment, does not attempt any explanation of it; contenting himſelf with the account only of various particulars attending it. In brief, the experiment is as follows:

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The electrophorus, that is, a plate of ſome reſinous ſubſtance, as ſulphur, roſen, gum-lac, &c. is firſt excited, either by rubbing, or otherwiſe; then a piece of metal of any ſhape at pleaſure, as, for inſtance, a three-legged compaſs, a piece of braſs tube, or the like, is ſet upon the electrophorus; and to this piece of metal, ſo placed, a ſpark is given of the electricity contrary to that of the plate. This done, the piece of metal is removed by means of a ſtick of ſealing-wax, or other electric; and ſome powder of roſen, kept in a linen bag, is ſhaken upon the electrophorus. This powder will be found to fall about thoſe points upon the plate which the piece of metal touched, forming ſome radiated appearances much like the common repreſentations of ſtars; at the ſame time upon the greateſt part of the plate, that is, in all parts except where the ſtars are formed, there is hardly any powder at all. Now it is to be remarked, that if the plate be excited negatively, and the ſpark given to the metal ſet upon it, be poſitive, the appearance will be as above deſcribed; but if on the contrary the plate is poſitive, and the ſpark is negative, then the powder of roſen will be found to fall upon thoſe parts of the plate, which in the other caſe are left uncovered; and to leave the ſtars clean: in ſhort, it will do juſt the reverſe of what it did in the other caſe: or, in other words,

words, the powder of roſin will be attracted by thoſe parts only of the electrophorus, which are electrified poſitively.

When I firſt obſerved theſe phenomena, I thought that there was no apparent reaſon why the powder of roſin ſhould be attracted by thoſe parts of the electrophorus, which are in a poſitive ſtate of electricity, and not by thoſe, which are negative. The two electricities are certainly contrary to one another; but either of them attracts a non-electrified body. On this conſideration I thought, that the experiment could be explained only upon the ſuppoſition, that the powder of roſin, on its falling from the linnen bag, was actually electrified negatively; in which caſe it would have been eaſy to account for the phenomena upon the well known principle of bodies attracting each other when they are contrarily electrified; and repelling one another when they are poſſeſſed of the ſame kind of electricity.

In order to try the reality of my ſuppoſition by experiments, I inſulated a braſs plate upon a glaſs ſtand, and connected a very ſenſible electrometer with it; and then began ſhaking the powder of roſin upon it, in the ſame manner as I had done upon the electrophorus, and in a few ſeconds of time had the pleaſure to ſee the electrometer diverge with a very manifeſt degree of negative electricity, anſwering my expectations exactly.

The explanation of the ingenious Profeſſor LICHTENBERG's experiment now became very eaſy and natural; for the powder of roſin, being actually electrified negatively, could not be attracted, except by thoſe parts of the electrophorus, which are in a contrary ſtate, that is, electrified poſitively.

It is obſerved, that powder of roſin anſwers better for this experiment than the powders of other ſubſtances; and accordingly I find, that this powder, when ſhaken upon the inſulated braſs plate, ſhews a ſtronger degree of electricity than the other powders. Indeed the electricity of the powder of roſin, not only when ſhaken upon the braſs plate in the manner above mentioned, but ſimply let fall upon it from a piece of paper, a ſpoon, &c. is remarkably great; half an ounce of it being ſufficient to make the threads of the electrometer diverge as much as they poſſibly can.

This diſcovery not only affords an eaſy explanation of Profeſſor LICHTENBERG's experiment upon the electrophorus, but ſhews a method of exciting powders, which has long been a *deſideratum* in the ſcience of electricity. The method is as follows; inſulate a metal plate upon an electric ſtand, and connect with it a cork-ball electrometer;

then the powder required to be tried being held in a ſpoon, or other thing, about ſix inches above the plate, is to be let fall gradually upon it. In this manner the electricity acquired by the powder, being communicated to the metal plate and to the electrometer, is rendered manifeſt by the divergence of the threads, and its quality may be aſcertained in the uſual manner. See fig. 4.

It muſt be obſerved, that if the powder is of a conducting nature, like the amalgam of metals, ſand, &c. it muſt be held in ſome electric ſubſtance, as a glaſs phial, a plate of ſealing wax, or the like. The metal ſpoon that holds the powder may alſo be inſulated; in which caſe, after the experiment, the ſpoon will be found poſſeſſed of an electricity contrary to that of the powder.

In performing theſe experiments care muſt be had to render the powders, and whatever they are held in, as free from moiſture as poſſible, it being ſometimes neceſſary to make them very warm, otherwiſe the experiments are apt to fail.

The following are the particulars I have obſerved with this new method, which, however, are neither numerous nor often repeated; but they may ſuffice to excite the curioſity of thoſe perſons who have leiſure and the opportunity of repeating them more at large, and in a greater variety.

Powder of roſin, whether it be let fall from paper, glaſs, or a metal ſpoon, electrifies the plate ſtrongly negative; the ſpoon, if inſulated, remaining ſtrongly poſitive. Flower of ſulphur produces the ſame effect, but in a leſs degree.

Pounded glaſs, let fall from a piece of paper, made dry and warm, electrifies the plate negatively, but not in ſo ſtrong a degree as roſin. If it is let fall from a braſs cup, it electrifies the plate poſitively, but in a very ſmall degree.

Steel filings, let fall either from a glaſs phial or paper, electrified the plate negatively; but braſs filings, treated in the ſame manner, electrified the plate poſitively.

The amalgam of tin-foil and quickſilver, gunpowder, or very fine emery, electrify the plate negatively when they are let fall upon it from a glaſs phial.

Quickſilver poured from a glaſs phial electrifies the plate poſitively.

Soot from the chimney, or aſhes from common pit coals mixed with ſmall cinders, electrify the plate negatively, when they are let fall from a piece of paper.

Deſcription of the improved atmoſpherical electrometer.

Fig. 2. is a geometrical repreſentation of my new atmoſpherical electrometer in its real ſize. This inſtrument, the firſt hint of which I received from my ingenious friend THOMAS RONAYNE, Eſq. after various trials, I brought to the preſent ſtate of perfection as long ago as the year 1777; and immediately after ſeveral of them were made after my pattern by Mr. ADAMS, philoloſophical inſtrument maker in Fleet-ſtreet. The great difficulty attending the conſtruction of this inſtrument has long diſſuaded my publiſhing any deſcription of it; nor had I ever troubled the Royal Society with it if the obſervations of ſeveral of my friends, who have uſed it in England and abroad, joined to my own repeated experiments, had not indiſputably confirmed its ſuperiority over any other inſtrument of that kind. Its particular advantages are, 1. The ſmallneſs of the ſize. 2. Its being always ready for experiments, without fear of entangling the threads, or having an equivocal reſult by the ſluggiſhneſs of its motion. 3. Its being not diſturbed by the wind. 4. Its great ſenſibility: and 5, its keeping the communicated electricity longer than any other electrometer hitherto uſed.

The principal part of this inſtrument is a glaſs tube CDMN, cemented at the bottom into the wooden piece AB, by which part the inſtrument is to be held when uſed for the atmoſphere, and it alſo ſerves to ſcrew the inſtrument into its wooden caſe ABO, fig. 1. when it is not to be uſed. The upper part of the tube CDMN is ſhaped tapering to a ſmaller extremity, which is entirely covered with ſealing wax melted by heat, and not diſſolved in ſpirits. Into this tapering part a ſmall tube is cemented, which, with its under extremity, touches the flat piece of ivory H, faſtened to the tube by means of cork. The upper extremity of the wire projects about a quarter of an inch above the tube, and ſcrews into the braſs cap EF, which cap is open at the bottom, and ſerves to defend the waxed part of the inſtrument from the rain, &c. In fig. 3. this braſs cap is repreſented as tranſparent, in order to ſhew its internal ſhape, and the manner in which it is ſcrewed to the wire projecting above the tube L. The ſmall tube L and the upper extremity of the large tube CDMN appear like one continued piece, on account of the ſealing wax which covers them both. The conical corks P of this electrometer, which by their repulſion ſhew the electricity, &c. are as ſmall as they can conveniently be made, and they are ſuſpended by exceedingly fine ſilver wires: theſe wires are ſhaped in a

ring

ring at the top, by which they hang very looſely to the flat piece of ivory H, which has two holes for that purpoſe. By this method of ſuſpenſion the friction is leſſened almoſt to nothing, and thence the inſtrument is ſenſible of a very ſmall degree of electricity. IM and KN are two narrow ſlips of tin-foil ſtuck to the inſide of the glaſs CDMN, and communicating with the wooden bottom AB; they ſerve to convey off that electricity, which, when the corks touch the glaſs, is communicated to it, and being accumulated might diſturb the free motion of the corks.

In regard to its uſe, this inſtrument may be uſed to obſerve the artificial as well as the atmoſpherical electricity. When it is to be uſed for artificial electricity, this electrometer is ſet upon a table or other convenient ſupport; then it is electrified by touching the braſs cap EF with an electrified body, which electricity will ſometimes be preſerved for more than an hour; in this ſtate, if any electrified ſubſtance is brought near the cap EF, the corks of the electrometer by their converging or diverging more, will ſhew the ſpecies of that body's electricity.

Before we proceed farther, it is neceſſary to remark, that the communication of any electricity to this electrometer, by means of an excited electric, for inſtance, a piece of ſealing wax (which we ſuppoſe as always electrified

trified negatively) is not very readily done in the uſual manner, becauſe of the cap EF being well rounded, and free from points or ſharp edges. By the approach of the wax the electrometer will be cauſed to diverge; but as ſoon as the wax is removed, the wires immediately collapſe. The beſt method to electrify it is, to bring the excited wax ſo near the cap that one or both the corks may touch the ſide of the bottle CDMN; after which they will ſoon collapſe and appear unelectrified. If now the wax is removed, they will again diverge and remain electrified poſitively. In this operation the wax does not impart any of its electricity to the electrometer, but only acts by means of its atmoſphere, *viz.* when the excited wax is firſt brought near the braſs cap EF (agreeable to the well known law of electricity, and according to Dr. FRANKLIN's hypotheſis) it determines the electric fluid, naturally belonging to the corks, towards the cap; hence the corks repel each other. Now if in this ſtate they touch the ſides of the glaſs CDMN, they acquire from it a quantity of electric fluid equal to that, which, by the action of the excited wax, was driven towards the cap, conſequently they collapſe and appear unelectrified. Notwithſtanding this appearance, the cap is actually overcharged, ſo that when the wax is removed, the overplus of the electric fluid, which the corks had acquired from

from the glaſs, and tin-foil ſtuck upon it, and which was crouded upon the cap, becauſe the negative atmoſphere of the wax now diffuſes itſelf equally through the cap, the wires, the corks, &c.; and, therefore, the corks repel each other with poſitive electricity.

If, inſtead of the ſealing wax excited negatively, an electric poſſeſſed of poſitive electricity be uſed, the electrometer acquires the negative electricity, and the explanation, *mutatis mutandis*, is the ſame as above.

By conſidering this remark it will appear, that when this electrometer is electrified, either poſitively or negatively, and an electrified body is brought towards the braſs cap; the electricity of that body will be of the ſame kind with that of the electrometer, if the corks increaſe their divergency; but it will be of the contrary kind, if the corks approach one another.

When this inſtrument is to be uſed to try the electricity of the fogs, the air, the clouds, &c. the obſerver is to do nothing more than to unſcrew it from its caſe, and, holding it by the bottom AB, to preſent it to the open air a little above his head, ſo that he may conveniently ſee the corks P, which will immediately diverge if there is any electricity; the kind of which, that is, whether poſitive or negative, may be aſcertained by bringing an excited

piece

piece of ſealing wax, or other electric, towards the braſs cap EF.

It is, perhaps, unneceſſary to remark, that this obſervation muſt be made in an open place, as the roads out of town, the fields, the top of a houſe, &c.

I have often made uſe of this electrometer in the roads between Iſlington and London, and by means of it I have confirmed the obſervation of Mr. RONAYNE, who firſt diſcovered the electricity of the fogs, as is teſtified by a paper of his publiſhed in the Philoſophical Tranſactions, and who has remarked, that a fog is very rarely not electrified; and that in clear froſty weather the air is conſtantly electrified.

Promiſcuous Experiments.

I. Having had frequent occaſion to obſerve how difficult it is to deprive ſealing wax of its electricity entirely, after that it has been well excited, I had the curioſity to try whether water could effect it. In order to that, I tied a ſtick of ſealing wax to a ſilk ſtring about a yard long, and after having excited it very powerfully with flannel, I plunged it in a tin veſſel full of water, and immediately drawing it out, brought a very accurate electrometer near it, and obſerved, that at firſt it ſhewed no ſign of electricity; but in about half a minute's time it manifeſted a ſmall but very ſenſible degree of negative electricity. A glaſs tube, treated in the ſame manner, was deprived of all its electricity by the water.

II. I have often remarked, that after having excited a glaſs tube with the amalgamated rubber in the uſual manner, the part of it which had been under my hand was negative. This minus ſtate was ſtill more conſpicuous when I graſped with my hand the part next above, *viz.* part of that which had been excited poſitively by rubbing. In the ſame manner, when I excite a ſtick of ſealing wax, by rubbing it with flannel, I often find, that the part of it which I hold in my hand is in a contrary ſtate of electricity, *viz.* poſitive.

III. Being deſirous of trying the conducting power of the effluvia of burning bodies in a manner more ſatisfactory than had hitherto been done, I contrived an inſtrument for that purpoſe, which is repreſented in fig. 5.(a).

The handle of it AB is a glaſs tube, into the extremity B of which a wire EI, and a ſmaller glaſs tube BC, are cemented

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(a) This inſtrument is juſt double the ſize of the figure.

mented by means of ſealing wax. From the extremity of this ſmall tube another wire FG proceeds, which, as well as the wire EI, is bent at the top, ſo that the extremities of both wires EF may be about one tenth of an inch from one another. GH is a ſmall wire faſtened to the wire FG, and to the extremity of the handle, ſo that when the inſtrument is held in one's hand, this wire touches the hand. K is a ſmall cork-ball electrometer, which, when the inſtrument is to be uſed, is affixed to the pin D, which proceeds from the wire IE. When experiments are to be tried with this inſtrument, the electrometer K muſt be affixed to the pin D, which proceeds from the wire IE, and muſt be electrified ſo that the cork balls may diverge as far as poſſible: this done, the extremities EF of the wires are brought within the effluvia that are to be tried, which, if they are of a good conducting nature, will complete the communication between the two wires EF, and diſcharge the electrometer of its electricity, otherwiſe the electrometer will remain electrified for a conſiderable time.

The experiments which I have made with this inſtrument are neither numerous nor ſo often repeated as to be depended upon, excepting one only, which, perhaps, it will be not uſeleſs to mention. I found that the fumes arising

Fig. 1.

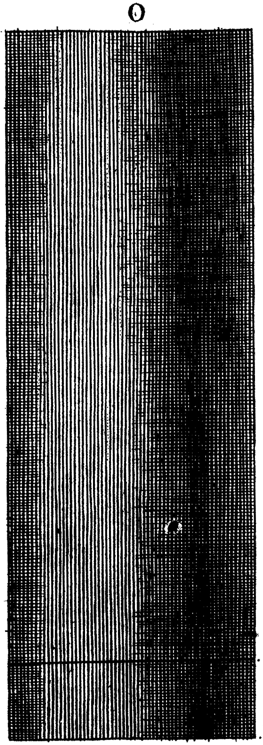


Fig. 2

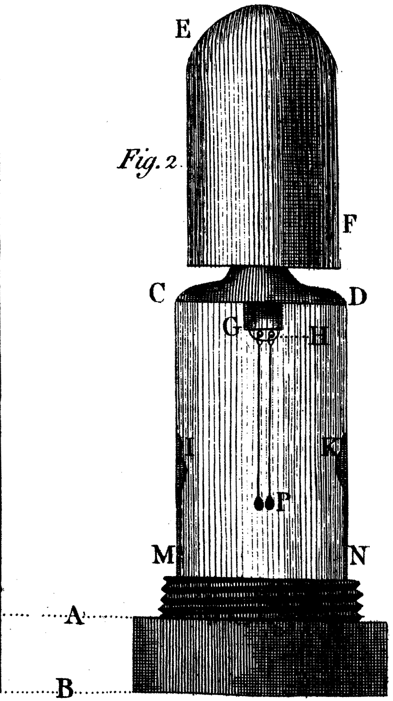


Fig. 3

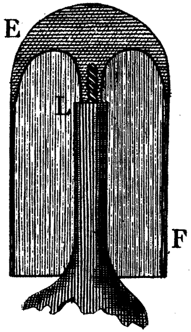


Fig. 4

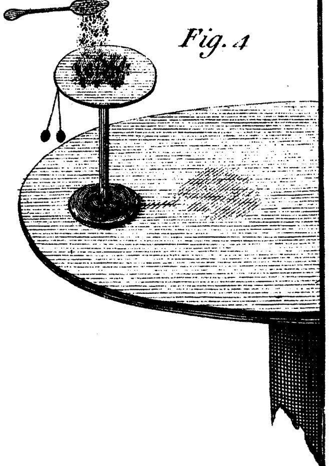
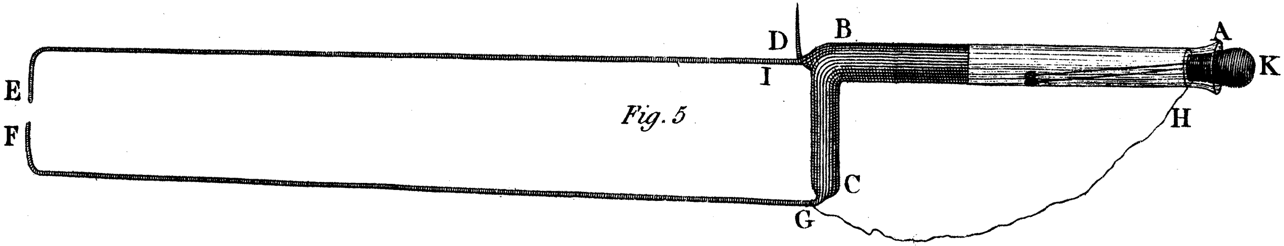


Fig. 5



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ariſing by the action of a lens, from the amalgam of tin-foil and mercury, conducted ſo badly, that the electrometer loſt its electricity in a time very little leſs than it would have done without any fumes whatever.

Little St. Martin's Lane,
Nov. 4, 1779.